

Circuit Arrangement for Operating an Exhaust-Gas Probe

Field of the Invention

5 The invention relates to a circuit arrangement for operating an exhaust-gas probe, especially an NOx probe.

Background of the Invention

10 Exhaust-gas probes of this kind are used in motor vehicles for determining the excess-air factor ( $\lambda$ ) and the NOx values. These exhaust-gas probes are, in most cases, operated so that the potentials of the electrodes are fixedly set in a controlled manner and the pump currents are measured. This can, for example, take place via so-called potentiostats which are conventional in electrochemistry. A typical control circuit of such a potentiostat is disclosed, for example, in the publication  
15 of A. J. Bard entitled "Electrochemical Methods" (1980), Fig. 13.4.6.

20 Control circuits of this kind include several operational amplifiers which all have different offsets. These different offsets of the operational amplifiers lead to errors in the measuring result of the exhaust-gas probes.

25 The offsets of the individual operational amplifiers add to a sum which is difficult to determine and which is also especially dependent upon temperature. To obtain a precise measuring result, a trimming of the individual operational amplifiers and their temperature characteristics is necessary.

Summary of the Invention

30 It is an object of the invention to provide a circuit arrangement for operating an exhaust-gas probe which is so improved that the circuit arrangement makes possible the adjustment of the potentials having respective offsets which

differ very little relative to each other.

Especially the above-mentioned matching or trimming of the operational amplifiers is to be avoided with the circuit arrangement of the invention.

5           The circuit arrangement of the invention is for operating an exhaust-gas probe including a NOx double chamber sensor. The exhaust-gas probe includes: a heatable solid-state electrolyte body having first and second pump chambers; diffusion barriers for separating the chambers from each other and from the exhaust  
10 gas; a third chamber communicating with the atmosphere; an external pump electrode exposed to the exhaust gas; a first oxygen pump electrode disposed in the first pump chamber; a second oxygen pump electrode disposed in at least one of the first and second pump chambers; a nitrogen oxide pump electrode  
15 disposed in the second pump chamber; an air reference electrode disposed in the third chamber; and, the circuit arrangement including: circuit means for applying pregivable voltages to the electrodes, respectively, and for generating, in a controlled manner, the following: a first oxygen pump current between the  
20 first oxygen pump electrode and the external pump electrode; a second oxygen pump current between the second oxygen pump electrode and the external pump electrode; and, a nitrogen oxide pump current between the nitrogen oxide pump electrode and the external pump electrode; and, the circuit means including: only  
25 one pump voltage generating circuit unit; switching means for switching the pump voltage generating circuit unit between respective ones of the pump electrodes; and, the pump voltage generating unit functioning to generate, in a controlled manner, all of the voltages applied to the pump electrodes in dependence  
30 upon respective reference voltages.





arrangement in accordance with an embodiment of the invention;

FIG. 3 is a schematic circuit diagram of an integrator of the circuit arrangement shown in FIG. 2; and,

FIG. 4 shows a current measurement amplifier of the circuit arrangement shown in FIG. 2.

#### Description of the Preferred Embodiments of the Invention

An exhaust-gas probe in the form of an NOx double chamber sensor is shown in FIG. 1 and includes two pump chambers (1, 2) arranged in a solid electrolyte body 11. The pump chambers (1, 2) are connected to each other and to the exhaust gas 5 via diffusion barriers (3, 4). A third chamber 6 is connected to the ambient air and contains an air reference electrode 7.

In the first pump chamber 1, the oxygen is pumped away with the oxygen pump electrode 8 and, for this purpose, a second oxygen pump electrode 9 is used in the first and/or second pump chamber 1 or 2. An NOx pump electrode 10 is mounted behind or under the second oxygen pump electrode 9 and nitrous oxide is pumped away with the NOx pump electrode 10. The pump electrodes (8, 9, 10) are arranged in the solid state electrolyte body 11 which, for example, can comprise ion-conducting zirconium oxide.

An insulated heater having insulating layer 12 is arranged at the lower side of the sensor. The potentials of the pump electrodes (8, 9, 10) are adjusted to fixed values compared to the air reference electrode 7 via an electric control circuit (not shown in FIG. 1). A possible adjustment can, for example, be undertaken as follows:

Oxygen pump electrode 8: reference point 0 V,

Air reference electrode 7: +300 mV,

Oxygen pump electrode 9: -100 mV,

NOx pump electrode 10: -105 mV.

For exhaust-gas probes of this configuration, it is purposeful to adjust the potentials via electrodes in a fixedly controlled manner and to measure the pump currents. This takes place via the circuit which will be explained in connection with FIG. 2.

FIG. 2 shows the circuit block diagram of a circuit arrangement for operating the NOx double chamber sensor shown in FIG. 1. In FIG. 2, the following abbreviations are explained:

APE: external pump electrode 13,

NOMESS: NO pump electrode 10,

O2MESS: oxygen pump electrode 9,

LR: air reference electrode 7,

IPE: oxygen pump electrode 8.

Periodically, three voltage desired values are applied to the inverting input of an operational amplifier 210 via a circuit means 222, which can, for example, be configured in CMOS technology. The three voltage desired values are, for example, 300 mV, -100 mV and -105 mV. The voltage desired values are generated via a precise voltage source 230, for example, a band-gap reference having voltage dividers R2, R3, R4 as shown in FIG. 2. The operational amplifier 210 compares the voltage desired values to actual values at the electrodes LR, O2MESS and NOMESS. The selection of the actual value takes place synchronously with the selection of the desired value likewise via a switch means which switches the actual values at the electrodes to the non-inverting input of the operational amplifier 210. The amplified fault signal is applied to the output of the operational amplifier 210 and reaches respective

ones of three integrators (241, 242, 243) via a further switching means 223 which operates synchronously. The three integrators (241, 242, 243) integrate the fault signal.

A circuit example of such an integrator is shown in FIG. 3 and is, for example, realized by an operational amplifier in an integrator circuit. The reference voltage  $U_R$  is applied to the non-inverting input shown in FIG. 3 and is a fixed dc voltage which can be suitably selected. Current measuring circuits (251, 252, 253) are arranged at the outputs of the integrators (241, 242, 243). The current measuring circuits (251, 252, 253) measure the currents flowing into the sensor electrodes APE, NOMESS and O2MESS and supply the voltage values  $U_{APE}$ ,  $U_{NO}$  and  $U_{O_2}$  which are proportional thereto. A circuit for such a current measuring voltage is shown in FIG. 4 and can, in turn, be realized by an operational amplifier.

The circuit means (221, 222 and 223) are switchable via a clock generator 220 which effects the periodic switchover at a frequency which lies typically in the kilohertz range. The primary advantage of the above-described circuit arrangement is that the offsets of the operational amplifiers do not operate on the control of the voltages at the electrodes LR, O2MESS and NOMESS within the integrators (241, 242, 243) as well as the current measuring circuits (251, 252, 253). Only the offset voltage of the control amplifier in the form of the operational amplifier 210 operates on the voltages at these three electrodes in the same manner because the operational amplifier 210 generates voltages at all three electrodes via the clocked synchronous operation of switching means (221, 222, 223). And an offset, which operates on all electrodes in the same manner, is not critical with respect to the function of the exhaust-gas

probe because only differences of the detected signals are of significance.

5 It is understood that the foregoing description is that of the preferred embodiments of the invention and that various changes and modifications may be made thereto without departing from the spirit and scope of the invention as defined in the appended claims.

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